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Automated data processing/simulation requirements of the Marine Corps tactical support activity

Hackert, Nancy Jeanne

Monterey, California. Naval Postgraduate School

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THESIS

AUTOMATED DATA PROCESSING/SIMULATION
REQUIREMENTS OF THE MARINE CORPS TACTICAL
SYSTEMS SUPPORT ACTIVITY

by

Nancy Jeanne Hackert

October 1982

Thesis Advisor: N. R. Lyons

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With the emergence of increased numbers of communications, command and control systems, and the expanding dependence on automated systems, there exists within the Marine Corps a requirement to define and control tactical systems software as a configuration item. The Marine Corps Tactical Systems Support Activity (MCTSSA), designated as the primary software support activity for these systems, must define and acquire the

necessary automated data processing hardware to achieve this future state. In addition, MCTSSA's mission requires software maintenance and testing, requiring a simulation facility. Current and future demands for computer support far exceed MCTSSA's existing capacity. One solution to the simulation/testing facility requirements is the subject of research and this paper.

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Automated Data Processing/Simulation Requirements of the Marine Corps Tactical Systems Support Activity

by

Nancy Jeanne Hackert
Major, United States Marine Corps
B.S., University of Maryland, 1969

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ABSTRACT

With the emergence of increased numbers of communications, command and control systems, and the expanding dependence on automated systems, there exists within the Marine Corps a requirement to define and control tactical systems software as a configuration management item. The Marine Corps Tactical Systems Support Activity (MCTSSA), designated as the primary software support activity for these systems, must define and acquire the necessary automated data processing hardware to achieve this future state. In addition, MCTSSA's mission requires software maintenance and testing, requiring a simulation facility. Current and future demands for computer support far exceed MCTSSA's existing capacity. One solution to the simulation/testing facility requirements is the subject of research and this paper.

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I. COMMUNICATIONS, COMMAND AND CONTROL

The purpose of this chapter is to describe the concept and characteristics of tactical systems in general terms. The first section will describe the characteristics of the generic communication, command and control system and also describe the considerations of the design of such systems. The emphasis will be placed on the features which relate to the Marine Corps concept in the tactical systems arena. The next chapter will describe the Marine Corps' approach to communication, command and control followed by the Marine Corps Tactical Systems Support Activity's functions and characteristics.

A. GENERAL CHARACTERISTICS

The growing scope of large on-line communication systems has generated increasing burden on computer technologies. These systems are characterized by a)sensors, b)telecommunications, c)displays, and d)computers. The primary task of these systems is to provide accurate real-time information status for problems confronting an organizaiton. These systems will provide an organization the means for decision making. The decision making may be automatic or manual and may be conducted by top level management or low down the chain of command. For example, in airline seat reservations, decision making is done automatically, whereas in medical diagnostics it is done manually with the machine merely presenting information. These systems consist of a complex set of procedures and devices which supply operational and administrative information for decision making and also the instruments for implementing these developments.

The main feature of these systems is that the whole performance is conducted in a closed loop. Decisions are made at upper levels and there exists constant feedback from lower levels to indicate execution of these commands. The closed loop principle thus ensures a more efficient control of the organization's resources. Various terms have been used to describe these complex systems, but the broadest and most appropriate is communications, command and control (C3). C3 in essence is the centralization and coordination of sets of various resources which are physically remote from the central location and use all the required techniques available. Several examples of C3 applications are: airline seat reservations, medical centers for automatic patient care, air traffic control, traffic configuration, remote bank accounting and transportation system planning.

The main requirement in all these diverse applications is the requirement for central coordination of the resources that are located over a scattered geographical area. It should be emphasized that the center of C3 systems is the "man". Computers are used only as a tool in assisting people in the aquisition and appraisal of information. [Ref. 1] Figure 1.1 is a schematic of a general C3 system configuration which includes a number of remote terminals that can communicate with a central computer.

C3 systems may be comprised of various computers with varying responsibilities, all operating independently. The systems are further complicated by the distance between terminals and the central computers, different types of terminals, large volume of information flow and diversity of processes. C3 must be considered a collection of systems using different techniques and possibly different computers. Although each particular system may be regarded as a system in its own right, in conjunction, the systems operate as a single unit. A major problem confronting the C3 system is

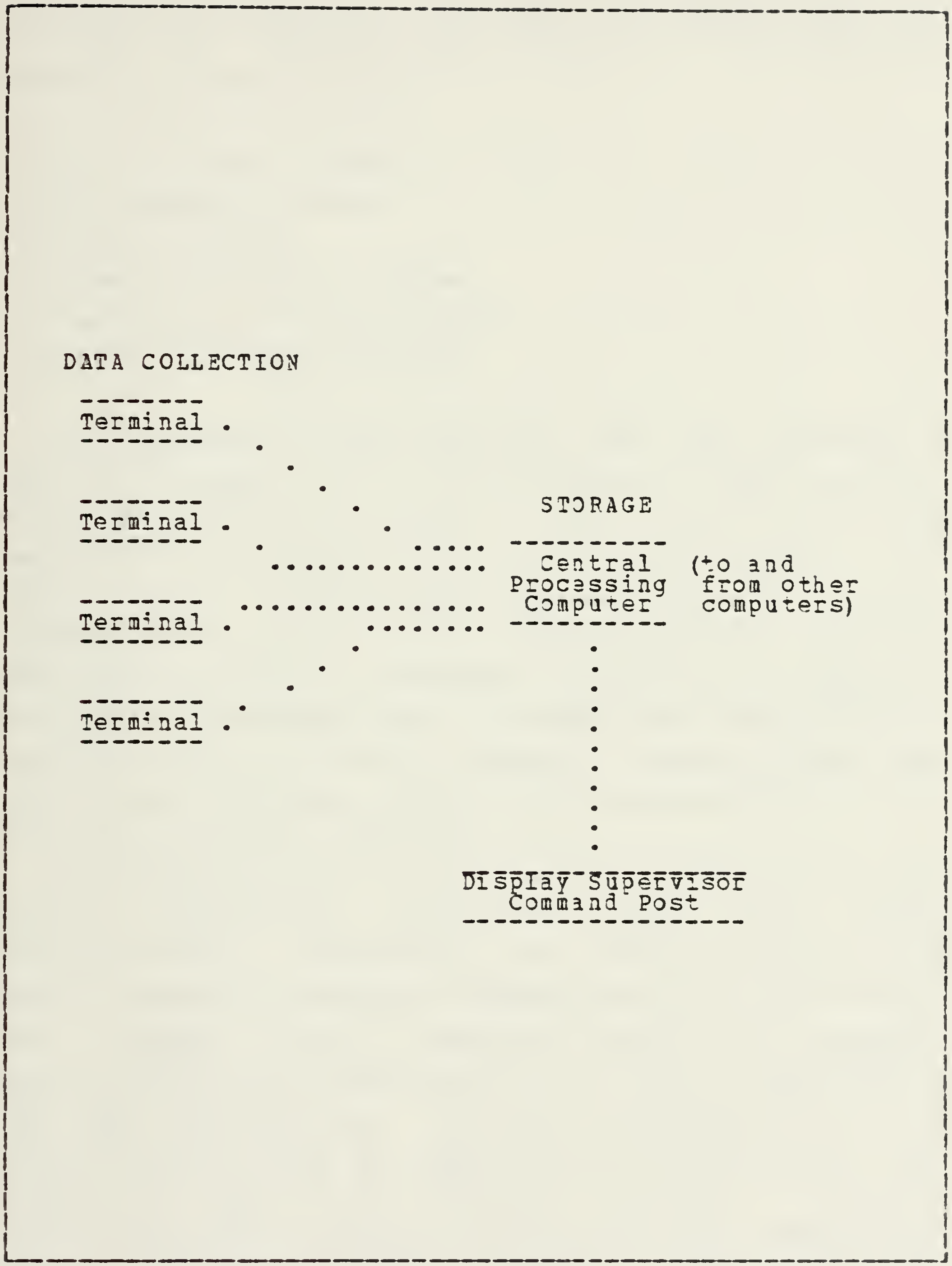

Figure 1.1 C3 System Configuration.

the interface between the different techniques. There are at least six functions which make up a communications command and control system:

- data collection systems
- data execution systems
- display systems
- command supervisory systems
- communication network systems
- central processing systems

The hierarchy of these functions and their interface is depicted in Figure 1.2 It is difficult to state the dominating factor of the C3 system; each function has the same importance and failure of one will cause failure of the entire system. Yet from the designers point of view the communication network is the most important and from the user point of view the essential feature of the system is the command supervisory post. Although each function may be intended for a particular operation several systems may share common equipment, such as the communication network, processing or display systems.

The performance of a C3 system may be divided into two types of operations: management systems which require continuous human intervention, and control systems which provide decision information automatically with the supervision of humans only to override decisions as necessary. Large C3 systems may incorporate both types of operations in the same configuration. The whole performance of a C3 system centers around the supervisory or command post. The command post performs the following funcitons: evaluation of the situation, decision making, issuing commands and pursuing the execution of the commands. The type information presented to the command post is: static data, dynamic

data, new operational data update in a real-time mode, follow-up data of the execution of the commands and plans of the organization.

Since each C3 system is intended for a specific application it would be impossible to list all the benefits of all such systems. The list below contains the highlighted benefits of C3 systems:

- centralizing the organizations efforts to control and monitor resources
- release of operator efforts from routine tasks to the evaluation, analysis and decision making
- data collection from remote sources at high speeds
- correlation of collected data from remote sources in real-time
- remote access to files in real-time
- less reliance on human memory
- display of on-line, real-time information for decision making
- shortening the time between location of problems at remote stations to their presentation at a central location
- means for feedback control on execution of decisions
- efficient utilization of communication networks
- concise, accurate and timely display of alarm situations
- immediate detection of degradation of performance
- automatic fault checking

The next section will describe some of the salient design considerations that characterize communication, command and control systems. The primary features will be defined in general terms and areas which relate to the Marine Corps' tactical systems applications will be defined in detail.

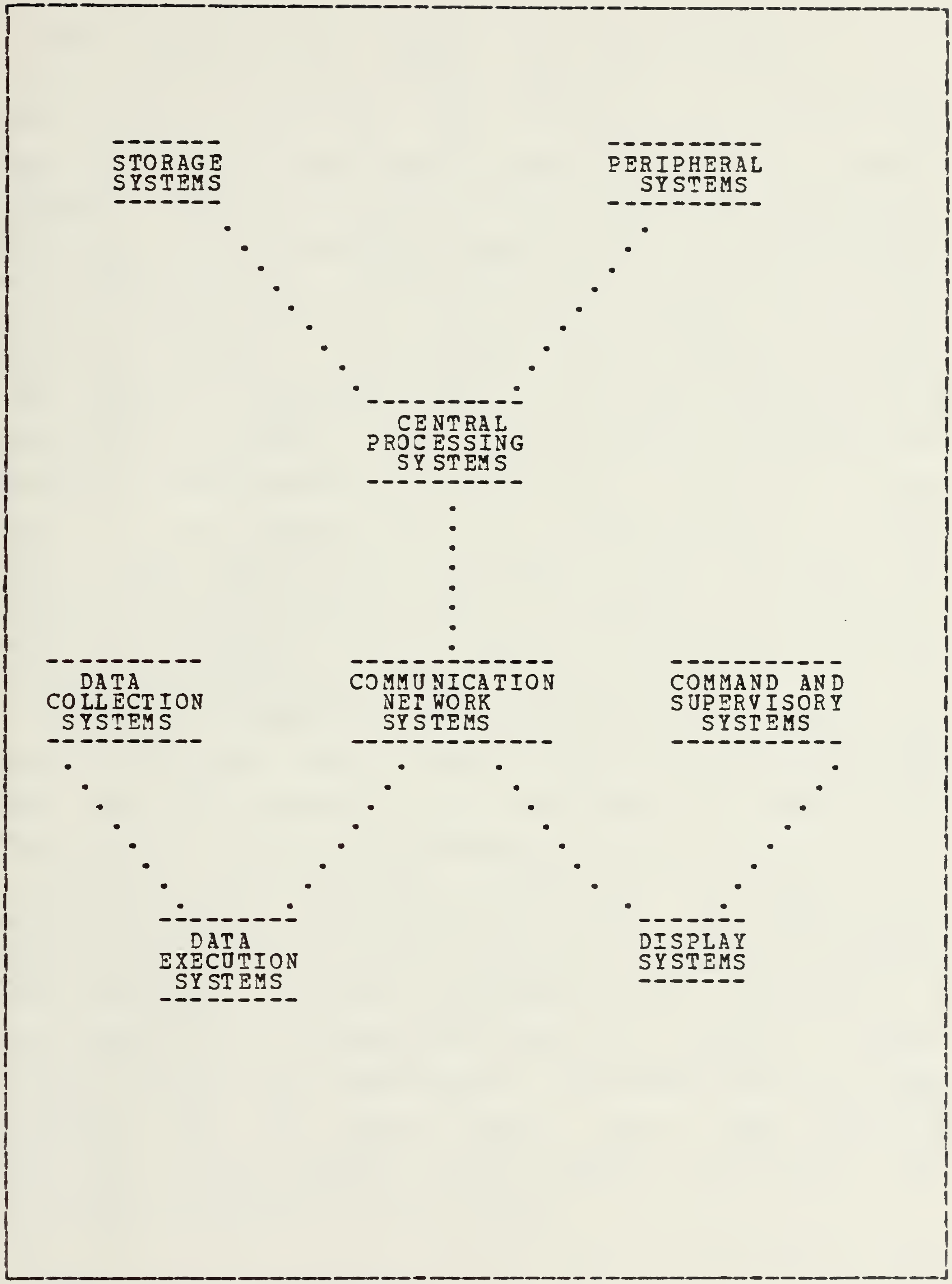

Figure 1.2 C3 Hierarchy of Systems.

B. DESIGN CONCEPTS

The purpose of a command and control system is to provide improved control of the organization by enabling top level management to know what is occurring at the lower levels so they can make their decisions in time to affect a process. The design purpose of the system must exploit all elements, at both upper and lower levels. The designer of the system normally reduces the design problems to a schematic; defining the data flow of the system showing all paths and branches. The designer must identify the system requirements and objectives and analyze what information the system has to deliver. The previous section described the command, communication and control (C3) system as a closed loop. At the design stage this is described as a "black box". The output from the black box must determine the nature of the information, when it is needed, who needs it, where it is needed, in what form it is needed and the relative priority treatment of the information.

The input details of the black box must consider what data is available, when it can be supplied, who supplies it, from where is it supplied, in what form it is supplied and the relative priority of scanning the data.

The next stage involved ensures that the data can be collected within a given period of time. The data must be adequate and it must be deliverable at necessary speeds so that situations requiring decisions can be controlled. A flow chart of the information should be outlined, demonstrating all the steps required in the system from the input terminals via the command post, up to the execution stations. The following points should be kept in mind throughout the design of the system:

- What were the operational problems that initiated the need for the new system?
- Would the new system solve all revealed problems?

- What are the respective responsibilities of the people involved in the new system?

- How does the human element fit into the system?

In all C3 systems the idea that the computer is the main implementing factor is an erroneous impression. Man-machine interaction is most important when computers are employed for problem solving and decision making. Analyzing the problem is inherently a computer task, while problem formulation lies exclusively with the human. It is vital that the computer and human communicate with each other. It is imperative to summarize where and how the sophisticated machine can assist the human operator:

- Release humans from routine tasks
- Divert humans to decision making
- Reduce the need for human memory
- Reduce human manual operations
- Increase the output by integrating simultaneous information
- Transfer repetitive tasks to machines

A good system design takes into account the complete system including all elements involved. The human must be considered one of the elements in the system. The system will not operate properly without the human. The computer literally may ask the human to provide further information and without this intervention the system ceases to operate. An initial decision then is what functions should be given to the machine and what distinctive part will the human play. Thus, a well-designed system must consider all aspects and considerations in a human-machine interaction. Table (I) lists several relevant points which apply to man-machine interaction.

TABLE I

DESIGN CONSIDERATIONS

FUNCTION	HUMANS	MACHINES
Analysis ability	Sophisticated	Superficial
Means of reception	Random	Sequential
Speed of reaciton	Slow	Fast
Type of reaciton	Sophisticated	Programmed
Problem attitude	Suspicious	Direct
Proneness to error	High	Low
Adaptation	After training	Programmed
Environmental affect	Output reduction	Immune

Two different design philosophies apply to C3 systems: 1) an automatic system where all the routine and repetitive decisions are carried out and performed by the machine and all doubtful and ambiguous information must be handled by humans, and 2) an automatic system where all routine and repetitive information is handled by the machine and relevant information is modified and presented to humans in summarized form. The humans supervise the running of the system and can override or cancel the machines execution of commands. There is no C3 system which does not contain a number of routine and/or repetitive operations which cannot be performed by the machine. Nevertheless there is always a need for some decision making based on ambiguities and unforeseen problems. Humans must verify these.

A C3 system may comprise many subsystems. Each may have its own operation and be developed independently. Nevertheless, all the subsystems are part of the large system supporting the same goal.

II. MARINE CORPS COMMUNICATIONS, COMMAND AND CONTROL

A. CONCEPTS

1. Background

During the mid-1960's, the Stanford Research Institute and Informatics, Inc., published the results of studies which encompassed the Marine Corps requirements in the area of command and control. The studies identified functional areas for which development was recommended. The five original functional systems included tactical combat operations, tactical air operations, Marine integrated fire and support, Marine integrated personnel and logistics and communications. The study recommended the establishment of a test bed consisting of off-the-shelf, commercially available computers, display devices, consoles, and communications equipment. The resulting concepts developed into the Marine Corps Tactical Command and Control System (MTACCS). In 1969 the Commander, Naval Electronic Systems Command was designated as the principal development activity for MTACCS. The Director, Development Center, Marine Corps Development and Education Center, was assigned the task of providing the prototype definition and analysis of the operational systems effectiveness.

MTACCS is part of the Marine Corps' Communications, Command and Control (C3) systems which will support tactical operations in the post-1980 time frame. It consists of seven tactical and training systems which utilize common equipment, operational procedures, data bases and interoperate through a common communications system. The seven MTACCS systems are:

-Marine Integrated Fire and Air Support System

- Tactical Combat Operations System
- Marine Air-Ground Intelligence System
- Position Location Reporting System
- Marine Integrated Personnel System
- Tactical Warfare Simulation, Evaluation, and Analysis System
- Tactical Air Operations Central - 1985

Development and fielding of the above systems constitute the major thrust in defining the C3 requirements of Marine Corps tactical forces. Appendix A describes some considerations for Marine Corps tactical data systems' communications.

2. Objectives

The objective of C3 within the Marine Corps is to provide Fleet Marine Force (FMF) commanders with command and control (C2) means to operate on the post-1980 battlefield. This encompasses the automatic, processing, display and distribution of information. The unique Marine Corps requirements stem from the diverse elements needed to accomplish the amphibious assault mission.

In 1961 the support for equipment developed under the Marine Tactical Data Systems Program was provided by Marine Air Control Squadron-3 (MACS-3), 3rd Marine Aircraft Wing, Santa Ana, California. The completed studies described above determined that MACS-3 could not support the anticipated accelerated growth of Marine Corps tactical systems. In 1968 it was recommended that the Marine Corps Tactical Computer Programming Support Acitivity be established to support tactical data systems computer programs for presently fielded and future systems. In May 1970 the basic concept of the implementation plan was approved changing the name to the Marine Corps Tactical Systems Support Activity located at Camp Pendleton, California.

During July 1970, the Marine Corps Tactical Systems Support Activity (MCTSSA) was formed to meet the increasing demands of the Marine Corps for supporting and developing automated tactical systems. It was determined that supportability and standardization of both hardware and software could be attained through the centralization of related projects.

B. MARINE CORPS TACTICAL SYSTEMS SUPPORT ACTIVITY

1. Mission

The mission of the Marine Corps Tactical Systems Support Activity (MCTSSA) is to define concepts and requirements for designated conceptual command and control systems; to perform Developmental Test and Evaluation (DT&E) for designated tactical data systems and telecommunications and electronics equipment; to provide hardware and software maintenance support of systems and equipments assigned for DT&E; to assist Fleet Marine Force units in conducting Operational Test and Evaluation (OT&E) of tactical data systems and telecommunications equipments as feasible and when directed; to provide software management control and support of fielded tactical data systems; and to monitor the software design phase of project development.

2. Structure

MCTSSA is comprised of a Headquarters, Tactical Systems Support Branch, Tactical Systems Development Branch, Tactical Systems Test Branch and Amphibian Vehicle Test Branch. The Headquarters and Amphibian Vehicle Test Branch will not be referred to again in this document. The other three branches will be referenced with respect to their functional position in the Automated Data Processing and simulation structure discussed herein.

3. Function

The following tasks are accomplished by MCTSSA in the area of concept and requirement formulation:

- Develop operational concepts and define requirements for those tactical command and control systems assigned to MCTSSA for the conceptual phase of development
- Determine and validate accurate, complete and realistic user requirements to avoid costly modifications to hardware or software during development and/or procurement
- Produce the Required Operational Capability Document, the System Description Document and the Detailed Requirements Document
- Test, evaluate, analyze and refine operational procedures of the Marine Corps Tactical Control Systems (MTACCS)
- Develop or employ existing scenarios as a basis for MTACCS testing
- Prepare procedures, exercises, test plans and an analysis of the above to support branch operations
- Monitor technological hardware and software development
- Maintain configuration management for in-house developed software.

MCTSSA is responsible for the compatibility and interoperability testing of all Marine Corps command and control systems designated to participate in the Joint Interoperability of Tactical Command and Control System programs. MCTSSA monitors the progress of all operational and developmental projects from the manufacturing of preproduction models through the stages of acceptance testing and during delivery of production systems to the Marine Corps. MCTSSA provides software management control and program support for fielded tactical data systems and those tactical data systems assigned to it for developmental test and evaluation. Operational impact studies, trade-off analysis and feasibility studies related to tactical computer program design and proposed enhancement are accomplished at MCTSSA. Also, MCTSSA provides personnel and maintenance support for

tactical data systems and communication-electronic equipments assigned to it for DT&E, and operational and maintenance support of the tactical data systems and communication-electronic equipments organic to itself. MCTSSA evaluates engineering change proposals, unsatisfactory equipment reports and proposed changes to fielded equipment.

Finally, MCTSSA provides the computing facilities to support its mission. The computer facility is complex combination of both tactical and commerical computing resources to provide highly flexible system networks for development, programming, simulation and testing in support of Marine Corps Tactical Systems. The capabilities and functions of the computing facility will be discussed in detail relative to its integral role in the hardware, software and data link simulation requirements. Appendix B defines the Test and Evaluation elements and the policies that guide the accomplishment of Test and Evaluation within the Department of the Navy.

III. TACTICAL COMMUNICATIONS

The purpose of this chapter is to describe the tactical communications required to support and enhance the Marine Corps' tactical data systems and operational capabilities in a Marine Air Ground Task Force environment.

A. LANDING FORCE INTEGRATED COMMUNICATION SYSTEM

1. Description

The Landing Force Integrated Communication System (LFICS) is the Marine Corps' tactical communication network, consisting of all of the personnel, equipment and data required for communication within the Fleet Marine Force. LFICS is not a single system, but encompasses all communication assets which allow commanders to exercise command and control of assigned tactical forces. This includes single-channel point-to-point and net radio communication, tactical digital information links (TADIL's) and multi-channel communication. The LFICS provides all internal and external communication required to enable commanders to perform their assigned missions. The basic concept is to configure LFICS as a common user system to facilitate communication asset utilization at all echelons of command. Historically a single-channel radio provided internal tactical communication requirements. With the emergence of tactical data systems, digital communication equipment and automatic switch communication systems have been elevated to a primary role.

2. Data Links

LFICS hardware configurations will be tailored to meet the specific needs of the size force utilizing it. Whenever practical, LFICS will be configured as a common user system. The multi-channel/Unit Level Message Switch (discussed in the next section) will be the primary means of digital connection. The basic objective of LFICS is to achieve a fully digital communication environment. LFICS must accomodate the command and control needs of the commander by providing voice and data communication, provide interoperability with external systems, provide security for all traffic, allow for minimum disruption due to loss of switches and provide an orderly transition from an analog to digital environment. The tactical data links (TADIL's) and their uses are listed in Table (II).

TABLE II

LFICS Tactical Data Links

NAME	FUNCTION
NADGE Link-1	External Air Defense
TADIL-A	Combat Information
TADIL-B	Air Defense
TADIL-C	Aircraft
ATDL-1	HAWK
MDT	Multi-purpose
TACFIRE	HAWK

Within LFICS all communication equipments have been categorized into subscriber facilities, switching facilities, tactical communication control facilities or transmission systems. Subscriber facilities provide the users' interface with LFICS. This is accomplished via telephone, data terminal or tactical data system computer interface. Switching facilities provide the ability to interconnect switching factilities at different nodes.

Manual or automatic interconnection of voice or data subscriber circuits is provided. Tactical communication control facilities provide control, monitoring and testing capability for any circuits which access switching centers. Transmission systems perform the communication functions of modulation/demodulation, transmission, reception, timing, bit conditioning and transmission security.

LFICS will provide communication for the transfer of voice and data for inter and intra-tactical data system exchange. Rapid, reliable and secure transfer of voice and data information between system nodes is required. The communication center is a centralized agency where communication facilities are located and managed. The communication center normally manages the transfer of information not accomplished by an external agency, a tactical data system or an individual subscriber. LFICS provides the communication links for the communication center. Finally, LFICS provides service to the common users including automated information systems and radio battalions.

3. Computer Hardware

Table (III) lists the major computer equipment utilized to support LFICS.

B. UNIT LEVEL MESSAGE SWITCH

The Unit Level Message Switch (ULMS) will be fielded during 1984. The nomenclature is the AN/GYC-7.

1. Description

The ULMS AN/GYC-7 is a transportable 12-line message switch capable of "store-and-forward" service for real-time command and control data traffic. The AN/GYC-7 is configured into two-man portable modules. It will be capable of

TABLE III

LFICS Computers

NAME	DESCRIPTION
AN/AYK-14	General purpose 16-bit word digital computer designated as the Navy Standard Airborne Computer. Modular in and can be configured for variable applications. Consists of a central process with 128K externally expand-to 512K and 5 input/output channels. Operator and maintenance equipment are separate from main module.
AN/UYK-7	Ruggedized 32-bit word general purpose computer which can be configured as a single processor or multi-processor system. Basic system consists of a single processor, 48K of memory and 16 full duplex input/output channels. Thirteen additional 16K word memory modules can be added externally. Operator and maintenance equipment are separate from main module.
AN/UYK-20	Militarized 16-bit word general purpose computer. Includes a central processor, main memory expandable from 8K to 65K words and 16 full-duplex input/output channels. Operator and maintenance panel are part of the main module.

serving dedicated real-time subscribers and will accomodate a tactical message format. The ULMS accepts and sends tactical messages. The module consists of seven microprocessors which interface with telephone systems as well as radio channels. The system integrates communication hardware and software and manages the communication network. It has alternate routing capability and its primary subscribers are the tactical data systems. It will accept messages for up to 16 routing indicators. Users are permitted to communicate over dedicated trunks. The ULMS provides transparancy from one tactical data system to another. Highspeed communication terminals provide a sophisticated tactical data base management scheme. Currently there exists no simulation testing for the AN/GYC-7.

2. Hardware and Software

Table (IV) lists the major hardware and software components that comprise the system.

TABLE IV

ULMS Hardware and Software Components

COMPONENT	QUANTITY	CPU
Power Module	1	
COMSEC Module	1	
Operation Program	TBD	Z-80

Table (V) lists the test support, software generation and software packages required to support the system.

TABLE V

ULMS Hardware/Software Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
AN/GYC-7	ULMS		
MTACC System	Subscribers		
Tesdata MS-880	Hardware Monitor		
Microprocessor Development System	System Development		
Utility Loader		TBD	TBD
Test Generation		TBD	TBD
Operational Program		256K	Z-80
Resident Programs		TBD	TBD
UNIX V7 OS	Operating System		PDP-11/70
Programmer Workbench	Program Development		
C-Compiler	Compiler		
Editor	Utility		
Assembler	Utility		
Link/Loader	Utility		

C. POSITION LOCATION REPORTING SYSTEM

The Position Location Reporting System (PLRS) is being developed jointly with the U.S. Army. Initial PLRS delivery will be during 1984. The PLRS nomenclature is the AN/TSQ-129.

1. Description

PLRS will provide highly accurate, real-time, three-dimensional position locations and identification information for selected air and ground elements and vehicles who are PLRS-equipped. This information will be available to appropriate commanders within the Marine Air Ground Task Force in order to assist in maneuver control, fire support planning and coordination, conflict avoidance and other command and control functions. The PLRS information will be available to using units (system users) and the Master Unit (AN/TSQ-129). PLRS' primary function is to maintain precise location and identification of friendly elements. The PLRS usefulness will be enhanced with its integration with other Marine Tactical Command and Control Systems. PLRS will provide users capability to identify their location and obtain locations of other PLRS users, provide identification of friendly and foe functions, define restricted areas for troops and identify navigational lanes for aircraft. The principle of PLRS is a three-dimensional unit location based on the ranges between that unit and three other previously located known units. The range between two PLRS units is measured by the known time of transmission of a signal by the unit to be located to the recorded transmission arrival time at a receiving unit with a known location. Thus, the calculation of the unit location is geometric. PLRS is so accurate that it can be used as the basis for delivery of close air support, artillery fire or naval gunfire. The output from PLRS can be utilized at command and control center for decision making, sent to PLRS user units or displayed to the master unit.

2. Hardware

PLRS is housed in an air-transportable S-280 military shelter. It can be deployed by helicopter or vehicle. The Master Unit contains the network communication facilities, computers, data displays and related equipment to support an independent PLRS network. The Master Unit provides central management for the user units, provides two-way exchange of secure digital data between itself and a user unit and provides PLRS received data to command and control systems. The PLRS user unit consists of a transmitter-receiver and processor, packaged in a 20-pound manpack. The hand-held module and the control display panel comprise the input/output devices. Table (VI) lists the system hardware components.

TABLE VI

PLRS Hardware Components

COMPONENT	QUANTITY	CPU
Computer	2	AN/UYK-20
Computer	1	AN/UYK-7
Master Station Equipment	1	
Manpack Units	7	
Service Vehicle Units	2	1802
Auxiliary Ground Units	1	1802

PLRS consists of a master unit, alternate master unit, user units, surface vehicle units and airborne unit configurations. The position location post processor, a hardware and software combination located at a Direct Air Support Center or a Fire and Air Support Center will furnish position location information. The operational and simulated data links are unknown.

3. Software

Table (VII) lists the software programs that comprise the system.

TABLE VII

PLRS Software

NAME	DESCRIPTION	CORE	CPU
DCP Program	16 Operation Programs	704K	UYK-20/ UYK-7
UYK-20 Kernel		5K	UYK-20
UYK-7 Kernel		5K	UYK-7
User Control	User Unit Control	TBD	1802
URD Message		TBD	1802

The SIMPLRS program will provide simulated user units responses to master unit generated messages. SIMPLRS is a module of the DCP program. It is designed to generate messages at a master unit or a command and control center. Table (VIII) lists the test support, software generation and software packages required to support the system.

TABLE VIII

PLRS Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
Perkin-Elmer 7/32	Minicomputer		
AN/UYK-20	Minicomputer		
AN/UYK-7	Minicomputer		
AN/USH-26	Tape loader		
Data Reduction			
MS 880	Hardware monitor		
TBD	Printer		
TBD	Card Reader		
TBD	Disc Storage	704K	
1802	Emulation system		
PROM Burner			
CMS-2Y/2M Compilers			AN/UYK-20/ AN/UYK-7

IV. TACTICAL AVIATION-RELATED DATA SYSTEMS

The purpose of this chapter is to describe several major aviation-related Marine Corps tactical data systems and their required components.

A. TACTICAL AIR OPERATIONS CENTRAL-1985

The Tactical Air Operations Central-1985 (TAOC-85) will be fielded during 1985. The nomenclature for the TAOC-85 Operations Module (OM) is the AN/TYQ-23.

1. Description

The TAOC-85 will provide responsive real-time control of the Marine Air Ground Task Force air defense and all assets used against air threats to it. It is a command and control system that will have anti-air warfare capability, air traffic control capability, early warning and long range tactical capabilities. TAOC-85 will be utilized at the Tactical Air Operations Center (TAOC). The TAOC radar and identification friend or foe data is used to detect and identify intrusions into the Marine Air Ground Task Force airspace. Thus, the TAOC manages and controls airspace in its assigned area. Also it performs air traffic control functions beyond the air traffic control detachments' range. The TAOC serves as the hub for air control data for the Marine Aviation Command and Control Systems. It deals with real-time air control operations.

The basic TAOC-85 system element is the Operations Module (OM). It is housed in a 20-foot shelter. The OM provides capability for accepting target reports, automatic track correlation, identification, classification and weapon

selection and assignment; receiving and processing track information, orders, commands and status data from other commands control systems; processing input from console operators for entry, deletion or modification of stored information; and displaying on operator consoles real-time tactical air situation based on all system inputs, both manual and automatic.

2. Hardware

The OM is the building block for the TAOC-85. Full system funcitonal capability is provided by a single shelter. The following units are installed with each OM: radar interface units, computer units, mass memory units, mass memory loaders, operator console units, voice communication access units, communication interface units, internal radio units, digital communication units, printer units, recorder/reproducer units, power distribution units, and environmental control units. Table (IX) lists the hardware components that comprise this system.

The TAOC will provide responsive, real-time commands and control to all Marine Air Ground Task Force air assets. The TAOC-85 consists of operations modules configured with radars, communication equipment, support equipment and personnel.

3. Software

Table (X) lists the software programs that comprise the system.

Table (XI) lists the test support, software generation and software packages required to support TAOC-85.

TABLE IX

TAOC-85 Hardware

COMPONENT	QUANTITY	CPU
Computer	2	AN/AYK-14
Mass Memory Unit	1	
Mass Memory Loader	1	
Operator Control Unit	4	
Power Distribution Control Unit	1	
Communication Interface Unit	1	
Radar Interface Unit	1	
Voice Access Unit	4	
Radios	9	
Crypto Units	35	
Wire Line Adapter	12	
Recorder/ Reproduction Unit	1	
Printer	1	
Environmental Control	2	
Data Terminal	1	
Microprocessor	17	L-3120
Shelter	1	

TABLE X

TAOC-85 Software

NAME	DESCRIPTION	CORE	CPU
Operation Programs	13 Programs	564K	AN/AYK-14
Interface/Console/ Comm Unit Programs	9 Programs	172K	L-3120/Z80/ 8748/Z8002

4. Data Links

Interfaces, data links and test requirements are listed in Table (XII).

B. TACTICAL AIR COMMAND CENTRAL

The Tactical Air Command Central (TACC) is an operational automated air command system. The nomenclature for the TACC is the AN/TYQ-1.

TABLE XI

TAOC-85 Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
Radar			
TACC			
TAOC			
TDCC	Simulator, Monitor		
Tesdata MS-880	Data Reduction		
Computer			DEC 2060
Disk Drives			
Printer			
Tape Unit			
Terminals			
PROM Burner			
MTASS	System Support		
FORTRAN	Compiler		
MACRO 14/20	Compiler		
TOPS-20	OS		

TABLE XII

TAOC-85 Data Links

INTERFACING SYSTEM	OPERATIONAL LINK	SIMLULATED LINK
TACC	TADIL-A/B	TADIL-A/B
DASC	TADIL-B	TADIL-B
IHAWK	ATDL-1	ATDL-1
TAOC-85	TADIL-B	-
MATCALS	TADIL-B	TADIL-B
Aircraft	TADIL-C	TADIL-c
External	TADIL-A/B	TADIL-A/B
NATO	NADGE Link-1	NADGE Link-1
FASC	TADIL-B	TADIL-B
TACC	ULMS	ULMS
FASC	TADIL-B	ULMS
FAAD	-	TACFIRE/ATDL-1

1. Description

The TACC provides a means to coordinate all aspects of air command, control and defense. It interfaces with external air control agencies and provides a means to effect real-time input in air defense. The TACC is the principal air operations installation from which aircraft and air warning fucntion of tactical air operations are directed. It is the senior Marine air command and control system agency from

which the Marine Corps tactical air commander can direct and control air operations. The Tactical Data Communication Central is employed at the TACC and will be described in the next section.

2. Hardware

Table (XIII) lists the major hardware components that comprise this system.

TABLE XIII

TACC Hardware

COMPONENT	QUANTITY	CPU
Display Group Equipment	1	
Universal Console	5	
Command Console	1	
WASD	2	
Operations Central	1	
Planning Central	1	
Power Supply	1	
Large Screen Display	1	
Integrated Comm System	1	
Multi-channel Data Terminal	1	
Visual Display Terminal	2	
Printer	2	
Computer	1	AN/UYK-20
UHF Radio	6	

3. Support

Table (XIV) lists the test system/equipemt, software packages and software generation required to support the TACC system.

4. Data Links

Table (XV) lists the data link requirements for the TACC.

TABLE XIV

TACC Support

NAME	DESCRIPTION	CORE	CPU
TSP Test Bed	Simulator		
Computer			AN/UYK-7
Computer			AN/UYK-20
Serial Modem			
Display	Entry Terminal		
SIMTRACC	Data Link Simulator		
TAOC			
TDCC			
DASC			
Computer			PDP-11/40
Computer			CP-808
TSP	Simulation		AN/UYK-7
SETUP		10K	CP-808
SETUP			AN/UYK-7
PRESTORE			CP-808
Test Scenario Generation		10K	AN/UYK-7
SIMTRACC	Simulation		NOVA II
Program Development	10 Test Programs	290K	AN/UYK-20
Data Reduction	Test Program	28K	CP-808
Data Reduction	Test Program	50K	PDP-11/70
TACC Symbols	Test Program	4K	CP-808
Program Development System	Compiler		PDP-11/70
Multi-User Compiler Facility	Compiler		PDP-11/70

TABLE XV

TACC Data Links

INTERFACING SYSTEM	OPERATIONAL LINK	SIMULATION LINK
TAOC-85	TADIL-A/B	TADIL-B
FASC	TADIL-B	TADIL-B
DASC	TADIL-B, MDT	TADIL-B, MDT
NATO	NADGE Link-1	NADGE Link-1
External	TADIL-A/B, NADGE	-
MATCALS	TADIL-B	TADIL-B

C. TACTICAL DATA COMMUNICATION CENTRAL

1. Description

The Tactical Data Communication Central (TDCC) is a five-shelter tactical configuration which provides a means to communicate on various tactical information links in

support of Marine Air Command and Control Systems' operations. The system provides the capabiltiy to conduct high frequency voice and data operations. This system accomodates the operational software for the TACC and the TAOC. The nomenclature for the TDCC is the AN/TYQ-3.

2. Hardware

Table (XVI) lists the major hardware components that comprise this system.

TABLE XVI

TDCC Hardware

COMPONENT	QUANTITY	CPU
Computer	2	AN/UYK-20
Data Entry Terminal	1	
Printer	1	
Disk Unit	1	
X-Link Buffer	1	
Magnetic Tape Unit	1	
Data Bus Controller	1	
Crypto Device	1	
Communications Group	1	
Serial Modems	10	
Serial Crypto Device	10	
Data Terminal Group	1	
Data Terminal	1	
Comm Central	1	
Radio Set	2	

3. Software

TAble (XVII) lists the software programs that comprise the TDCC system.

4. TDCC Support

Table (XVIII) lists the test system/equipment, software generation and software packages required to support the TDCC system.

TABLE XVII

TDCC Software

NAME	DESCRIPTION	CORE	CPU
Operation Program	10 Programs	290K	AN/UYK-20
TACC Symbol Library		4K	CP-1018

TABLE XVIII

TDCC Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
TSP Test Bed	Simulation		AN/UYK-7, AN/UYK-20
TACC			
TAOC			
SIMTRACC	Data Link Simulation		
MATADOR IV	Data Reduction		CP-808
Tesdata MS-880	Performance Monitor		
CMS-2Y Compiler	Compiler		AN/UYK-7, AN/UYK-20, PDP-11/70
Tactical Data Reduction		28K	CP-808
Tactical Data Reduction		50K	PDP-11/70
Test Support		76K	AN/UYK-7
TSP SETUP		10K	CP-808
Test Scenario Generation		10K	AN/UYK-7
TSP		76K	AN/UYK-7
SIMTRACC			NOVA II
Program Development System	Compiler		PDP-11/70
Multi-user Compiler Facility			PDP-11/70

5. Data Links

Table (XIX) lists the data link requirements of the TDCC system.

D. DIRECT AIR SUPPORT CENTER

The initial system delivery for the Direct Air Support Center (DASC) is during 1982. The nomenclature for the DASC is the AN/UYQ-4A.

TABLE XIX

TDCC Data Links

INTERFACING SYSTEMS	OPERATIONAL LINKS	SIMULATION LINKS
TAOC	TADIL-A/B	TADIL-A/B
TACC	TADIL-A/B	TADIL-A/B
IHAWK	ATDL-1, NADGE Link-1	ATDL-1
NATO	NADGE Link-1	NADGE Link-1
External	TADIL-A	TADIL-A/B
Aircraft	-	TADIL-C

1. Description

The DASC is the principal air control agency responsible for the conduct of direct air support operations. It functions in a decentralized mode of operation but is directly supervised by the Tactical Air Control Center (TACC)/Tactical Air Operations Center (TAOC). The DASC is a command and control agency and is located with the highest Fire Support Coordination Center echelon. The AN/UYQ-4A is operational in either an airborne or mobile environment. The ranges and speeds of aircraft employed require that their control be directed from a high command level. The DASC is one of the primary control agencies of the Marine Air Command and Control System. The TAOC and the DASC interface indirectly by means of relay through the TACC. The DASC performs the following tactical functions: coordination of close air support, coordination of assault support missions, coordination of air reconnaissance missions, dissemination of friendly and enemy aircraft information and the control of aircraft returning from direct air support missions.

The DASC is comprised of three functional areas: communications, data processing and display. These functions provide for voice and data link communication, display of the tactical area of responsibility (TAOR), display of selected friendly aircraft tracks and related information,

computation and display of aircraft vector information for navigational purposes and automatic receipt and computation for display of target data.

2. Hardware

The DASC operational unit consists of three shelters. One shelter houses the computer, printer, communication panel, communication control unit and the encryption units. The other two shelters each house five situation display consoles, communication control units, digital communication units, communication panel, power distribution panel and the display console keyboards. Table (XX) lists the major hardware components that comprise the system.

TABLE XX

DASC Hardware

COMPONENT	QUANTITY	CPU
Operations/Data Processing/ Comm Shelters	4	
Integrated Comm System	1	
Display Control Unit	3	
Situation Display Console	13	
CPU	2	AN/UYK-7
Magnetic Tape Unit	2	AN/USH-26
TADIL-B Buffer	2	
TADIL-B Modem	2	
Comm Processor	24	
Speech Security Unit	6	
Remote Power Converter	1	

3. Software

Table (XXI) lists the programs that comprise the system.

TABLE XXI

DASC Software

NAME	DESCRIPTION	CORE	CPU
TBD	Program Trainer	128K	AN/UYK-7
TBD	Preprocessor Trainer	96K	AN/UYK-7
TBD	Interactive Processor	116K	AN/UYK-7

Table (XXII) lists the test support system/ equipment, software generation and software packages that support the DASC system.

TABLE XXII

DASC Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
TACC	Tactical Air Command Central		
TAOC	Tactical Air Operations		
TDCC	Tactical Data Comm Central		
DCT	Digital Comm Terminal		
CMS-2Y Compiler			AN/UYK-7
DCT Simulator			
TADIL-B Simulator			
TSP	Simulation	76K	AN/UYK-7
SETUP		10K	CP-808
SETUP			AN/UYK-7
PRESTORE			CP-808
Test Scenario Generation		10K	AN/UYK-7
SIMTRACC	Simulation		NOVA II
10 Test Programs		290K	AN/UYK-20
Data Reduction	Test Program	28K	CP-808
Data Reduction	Test Program	50K	PDP-11
TACC Symbols	Test Program	4K	CP-808

4. Data Links

DASC operators are trained on the operational equipment via a training program. Simulated testing provides capability to interact with the air support radar teams (ASRT), TAOC/TACC and the digital communication terminals. Other DASC requirements include data extraction, reduction and analysis which currently are not automated. Table (XXIII) lists the data links required for this system.

TABLE XXIII

DASC Data Links

INTERFACING SYSTEM	OPERATIONAL LINK	SIMULATION LINK
TACC	TADIL-B	MDT
ASRT	MDT	MDT
TAOC-85	TADIL-B	TADIL-B
DCT	MDT	-

E. MARINE AIR TRAFFIC CONTROL AND LANDING SYSTEM

The Marine Air Traffic Control and Landing System (MATCALS) will be fielded during 1983. The system nomenclature is currently unassigned.

1. Description

MATCALS is a deployable air-transportable, modular system. It provides upgraded capability to the Marine Air Command and Control System for handling high-density air traffic at expeditionary bases. MATCALS is organized into three sysbsystems: air traffic control, all-weather landing system and control and communication subsystem (C&CS). The C&CS consists of two 8X8X20 shelters. The air traffic control and the all-weather landing systems may be deployed separately. MATCALS provides all aspects of surveillance, identificaiton, tracing, aircraft vectoring and track hand-over. Within 60 nautical miles of the airfield the system provides for up to 40 aircraft tracks. The 15A19 is fully militarized and used to train air traffic controllers, weapons controllers, scanner classifiers, flight supervisors, communications specialists and flight control personnel in tactical environments. It prepares scenarios containing simulation flights of aircraft required to support close-air-support, air defense, air-to-air intercepts, ground to air missile control and ground-air-ground data link control. Communications nets include simulated

UHF/VHF and normal land-line communication links. The trainer realistically simulates the TAOC, missile batteries, ground-air-ground data links and multi-site communication.

2. Hardware/Software

The AN/UYK-20 computer and peripheral equipment is utilized in the shelter. All software is written in CMS-2 and an interactive scenario generation capability exists. The operational training device requires the computer, floppy disc unit, data link modems and a video display unit. The trainer consists of a simlulation cabinet which generates simulated radar signals for the training problem under the control of the computer program. The 15A19 includes a readiness program, scenario generation program and the main trainer program. Table (XXIV) lists the MATCALS hardware.

TABLE XXIV
MATCALS Hardware

COMPONENT	QUANTITY
Precision Approach Radar	1
Air Surveillance Radar	1
C&CS	2 shelters
Multi-Mode Display	20

3. Data Links

Table (XXV) lists the MATCALS data link requirements.

TABLE XXV

MATCALS Data Links

INTERFACING SYSTEM	OPERATIONAL LINK	SIMULATION LINK
TACC	TADIL-B	-
Aircraft	TADIL-C	TADIL-C
TAOC-85	TADIL-B	TADIL-B

V. TACTICAL GROUND-SUPPORT DATA SYSTEMS

The purpose of this chapter is to describe the major ground related tactical data systems utilized in the Marine Air Ground Task Force environment.

A. MARINE INTEGRATED FIRE AND AIR SUPPORT SYSTEM

The Marine Integrated Fire and Air Support System (MIFASS) will be fielded during 1986.

1. Description

MIFASS is a tactical data system which will automate selected functions currently performed by the Fire Support Center and the Fire Direction Center. It consists of procedures and equipment that will improve the command, control and coordination of the fire and air support assets of the Marine Air Ground Task Force. The system will provide commanders at all echelons with real-time display information. MIFASS will establish the Fire and Air Support Center (FASC) which will assume selected air control functions and control selected functions of artillery support. Real-time digital display and information processing will provide friendly unit positions, target locations and process requests for supporting arms. Control and coordination of all fire and air support will be exercised through the FASC. Aircraft routes, potential conflicts between fire weapons and aircraft flights will be automatically detected at the FASC via MIFASS. MIFASS will improve the overall employment of fire, air support and troop movement. It will ultimately operate with other Marine Corps automated command and control systems and will be compatible with Navy command and control agencies.

Each MIFASS center will operate independently. Display units will exchange selected information. Communication control and communication security will support the digital communication capability.

2. Hardware

MIFASS consists of suites of modular microprocessing and display equipment tailored to the level and type of command it supports. The system is transportable by all tactical means, will operate in a Marine Corps shelter, aboard ships and in tactical vehicles. All equipment is two-man portable. MIFASS equipment will perform control and coordination functions at all echelons. It consists of the dynamic situation display which represents graphic map symbology, air coordination areas and target areas; communication control panel for communication with various radio nets; hand-held input/output devices which will send and receive messages from other MIFASS centers; printers which will print hard-copy records of all messages into and out of the MIFASS center; computers which will drive all other equipment; auxillary mass memory; and digital and voice communication equipment. Table (XXVI) lists the major hardware components of the system.

3. Software

Table (XXVII) lists the programs the comprise the MIFASS.

Table (XXVIII) lists the systems and equipment, software generation and software packages required to support MIFASS.

TABLE XXVI

MIFASS Hardware

COMPONENT	QUANTITY	CPU
Dynamic Situation Display	19	
Printer	27	
Comm Control Panel	27	
Computer	15	AN/AYK-14
Fire Direction Calculator	9	
Mass Memory	13	
Mass Storage Device	4	
PM	15	
Battery Box	21	
Digital Comm Equipment	12	
Shelter	3	

TABLE XXVII

MIFASS Software

NAME	DESCRIPTION	CORE	CPU
Operation Programs	26 Programs	132K	AN/AYK-14
Digital Comm Equipment		TBD	Z8000
Fire Direction/ Survey Calculator, Comm Panel, Mass Memory		TBD	8085

TABLE XXVIII

MIFASS Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
Simulator			
Data Reduction			
Computer			DEC 2060
PROM Burner			
Microprocessor			Z8000
Microprocessor			INTEL 8085
Computer			AN/AYK-19
Simulation Package			
MTASS	System Software		DEC 2060
TOPS-20	Operating System		
LAMPS-14	Executive System		AN/AYK-14
PLZ	Compiler		INTEL 8085
MDS	Micro Development System		

4. Data Links

MIFASS will be capable of using existing communication systems. Each MIFASS center will interface with the digital communication system. This capability will provide for all data conversions, addressing, error handling and communication protocol actions. Table (XXIX) lists the data link requirements of the system.

TABLE XXIX
MIFASS Data Links

INTERFACING SYSTEM	OPERATIONAL LINK	SIMULATION LINK
FASC	ULMS	ULMS
PLRS	ULMS	ULMS
ASRT	MDT	MDT
TACC	TADIL-B	TADIL-B
TAOC-85	TADIL-B	TADIL-B
External	ULMS	ULMS

B. IMPROVED HOMING-ALL-THE-WAY KILLER (IHAWK)

IHAWK is a fielded joint service system. MCTSSA's involvement is to monitor evolutionary changes to ensure that future Marine Corps requirements are met.

1. Description

The HAWK is a mobile, surface-to-air, guided missile system designed to defend against low-flying enemy aircraft. The system includes the Information and Coordination Central, the Improved Platoon Command Post and miscellaneous radar and radio equipment.

2. Software

Table (XXX) lists the test system/equipment required to support IHAWK.

TABLE XXX

IHAWK Support

SYSTEM/EQUIPMENT	DESCRIPTION	CORE	CPU
ATDL-1 Simulator	Simulator Program		
TSP	3 Test Scenario Programs	86K	AN/UYK-7
SIMTRACC	Simulator		NOVA II
SETUP/Data Reduction		38K	CP-808
PRESTORE			CP-808
Testing Support	9 Programs	244K	AN/UYK-20
Data Reduction		50K	PDP-11

3. Data Links

The IHAWK interfaces with the Tactical Air Operations Center and other IHAWK units both operational and during simulation via the ATDL-1 tactical data link.

VI. DATA LINK SIMULATION

In the first section of this chapter the existing tactical data system simulation techniques currently being utilized are described. The second section describes a general purpose alternative software package which could accomodate the previously described requirements. Finally, several conclusions will be drawn on the specifications of a tactical data system simulation facility followed by an enumeration of data link simulation facility requirements.

"Simulation is the process of designing a model for a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system." [Ref. 2]

A. EXISTING SIMULATION PACKAGES

Data link simulation is used at MCTSSA to test new and improved tactical systems. There are two systems currently being used for data link simulation: the Simulator, Trainer, Command and Control (SIMTRACC) and the Test Support Program (TSP). SIMTRACC is an integrated hardware/software system which runs on a Data General Nova II computer. TSP is a software package which runs on an AN/UYK-7 computer. SIMTRACC can simulate various combinations of TADIL-A/B/C, ATDL-1 and NADGE Link-1 data links. TSP can simulate TADIL-A/B and computer to computer data links. SIMTRACC has data extraction, reduction and analysis capabilities. MATADOR IV, a separate software package, is used to reduce data from a TSP simulation.

1. <u>Simulator, Trainer, Command and Control</u>

The SIMTRACC system is used to simulate the outside world for various tactical systems. SIMTRACC supports simulation, testing, training and command and control functional areas. It can simulate the data links of any agency that meets specific protocols. SIMTRACC's primary use is data link simulation to support testing tactical data systems. A secondary use is to train TAOC operators. Data extraction and reduction can be performed on-line. It can handle up to 180 targets or air tracks with the capacity limited by the combination of type and number of links being simulated.

The SIMTRACC hardware consists of a Data General Nova II, a teletypewriter, keyboard, printer/plotter, disk unit, CRT controller, CRT, modems, bus repeater, cursor control pad and multiplexor. Approximately 15 programs comprise the system.

SIMTRACC processes the contents of a script file which consists of a time-tagged sequence of keyboard inputs. When the script time matches the time tag for the currently processed file, then the file inputs are injected into the data link system in the same format as keyboard real-time inputs. The scripting system consists of file creation, file item formats, execution control abd error processing. SIMTRACC performs data analysis to determine proper message structure, correct value ranges, correct transmission and accurate reporting responsibility. SIMTRACC is highly interactive and requires a well-trained operator.

2. <u>Testing Support Program</u>

The TSP is made up of three programs: TSP itself, SETUP and PRESTORE. TSP is a real-time interactive simulation system used for testing of digital data exchange of tactical data systems. TSP is capable of simulating those

portions of the tactical system that control the exchange of digital messages between individual systems and the program whose performance is being evaluated. This means of selective alteration constitutes the event capabiltiy of the system. The user can structure a dynamic exercise of any or all the data link functions. The maximum number of tracks allowed by the TSP software is 405. This capacity also is dependent upon the number of required data links.

The TSP runs on a stand-alone AN/UYK-7 computer. The hardware that comprises the system is an alphanumeric display unit, magnetic tape unit, high speed printers, paper tape unit, Univac CP-808 computer, card reader, disk unit and a PDP-11/70 computer. The SETUP and PRESTORE programs run on the CP-808 and PRESTORE also utilizes the PDP-11/70.

Data generated by an operator via the interactive display unit or data entered via card input contains TSP test data. An operator must go through a series of steps to set up and initialize the system equipment. The program prompts the operator for any additional required test data. There are 23 prescripted formatted events. Some messages are automatically built by the system. The test data contains system configuration data, action and background track data and prescripted events. Information such as latitudes and longitudes of system participants and simulated system actions that will be executed must be provided by the operator. The operator controls the simulation status and data associated with the simulation system and links.

3. Integrated Simulation Requirements

Figure 6.1 lists the minimum simulation capabilities that must be included in an integrated simulation facility at MCTSSA in the FY-84/85 timeframe.

a. Simulate TADIL-A, TADIL-B, TADIL-C, ATDL-1, NADGE Link-1, ULMS and MTACCS messages.

b. Simulate up to 10 concurrent TADIL-B links.

c. Simulate at least 500 tracks.

d. Simulate up to 13 concurrent links.

e. Simulate air and surface track processing.

f. Accomodate Scripting for TADIL-A, TADIL-B, TADIL-C, ATDL-1, NADGE Link-1, ULMS and MDT links.

g. Accomodate 24 participating units on TADIL-A.

h. Accomodate simulated moving participating units.

i. Simulate data extraction and reduction for TADIL-A, TADIL-B, TADIL-C, ATDL-1, NADGE Link-1, ULMS and MDT links.

j. Simulate forwarding units on TADIL-A and TADIL-B.

Figure 6.1 Integrated Simulation Facility Specifications.

4. Conclusions

The most desirable alternative to Marine Corps simulation requirements is an integrated simulation system based on distributed processing concepts and state-of-the-art mini and micro computers. SIMTRACC and TSP cannot be utilized in an integrated environment because they support only unique, disjointed test requirements. SIMTRACC will not accomodate future track capacity requirements and the agencies that can be simulated by TSP are limited. TSP cannot support any data collection for data analysis because of its inability to extract or reduce data during testing. TSP and SIMTRACC do not accomodate the data link testing growth expected at MCTSSA.

B. A SIMULATION ALTERNATIVE

Simulation models consist of continuous change models and discrete change models. Continuous models incorporate fixed increments of time advances and are interested in a continuous flow of information. Items are considered in aggregate rather than individual. Discrete models are interested in individual items in a system and utilize the next event type of timekeeping. Tactical data systems are primarily discrete change models. Simulation software assists in the performance of tasks performed during the evaluation and testing of communication, command and control systems.

Simulation Language for Alternative Modeling (SLAM) II is a software package which exemplifies the state-of-the-art in simulation. SLAM II permits discrete event, continuous and network modeling perspectives and any combination of the three. SLAM II can perform as a discrete change system that can be modeled from the point of view of events and/or processes. The process-oriented part of SLAM employs a network structure comprised of node and branch symbols. The modeling task consists of incorporating these symbols into a network model which represents the system pictorially. The modeler defines the events of the system and the potential changes that may arise in the system. SLAM II provides a set of standard subprograms that provide for scheduling, manipulating files, collecting statistics, and generating random samples. The modeler provides FORTRAN routines that describe the mathematical and logistical relationships of the changes that each event will produce. SLAM II permits entities in the network model to initiate occurrence of discrete events, events to alter the flow of entities in the network model, entities in the network model to cause instantaneous changes to values of the state variables, when

state variables reach threshold values they can initiate entities in the network model, events can cause instantaneous changes in the values of state variables and when state variables reach prescribed threshold values they can initiate events. The process-oriented (network) model consists of drawing possible paths (including delays) that an entity encounters from its arrival time to its departure time as in tactical data information flow.

The continuous model is coded by specifying difference equations which describe the dynamic behavior of the state variables. The modeler codes these equations in FORTRAN utilizing SLAM-defined storage arrays. The executive program controls the simulation by advancing time and initiating calls to the event subroutines. SLAM II is written in FORTRAN-66 and is upward compatible with FORTRAN-77.

VII. SIMULATION/TEST FACILITY SPECIFICATIONS

"Minicomputers and microcomputers rarely have the software and peripherals for convenient use. Programming small computers is tedious and time-consuming. The small computer that goes into the final product is generally not suitable for use in the developmental stage. Programs for large computers are developed on the same system on which they are used. Small computers, however, that are part of an instrument or machine tool will only have enough memory, peripherals and software to perform their function. The computer that goes into the system can handle system functions - not system development". [Ref. 3]

A. DESCRIPTION

1. Background

Currently, MCTSSA has two PDP-11/70's, three PDP-11/60's and one PDP-11/40. The PDP-11/70's are utilized for program development, compilation and testing. The operational fielded systems that are developed, maintained and tested in-house are the TACC, the TDCC, the DASC and the IHAWK system. The software comprises approximately 1200 programs and 220,000 lines of code. The PDP-11/60's are utilized for graphics output and terminal input and output. The PDP-11/40 is utilized as a front-end processor for hardcopy output.

The investment in software, programmer training and operational support with the current hardware configuration is enormous. The existing software comprises approximately 1800K words of memory. Thus, modification, upgrade or replacement must be economically feasible, compatible and relatively transparent.

2. General Characteristics

One solution to the simulation/test facility requirements described in previous chapters is the time-phased replacement of two PDP-11 developmental host computers with two VAX-11/780 computers. FORTRAN-77 is recommended as the high order programming language to be utilized for software development until ADA is entirely available and supported. The SIMTRACC devices should be reduced from five to two and SLAM II should be considered as an alternative general purpose simulation package. Figure 7.1 lists future capabilities that will be available.

a. Combination of 10 TADIL-B, ATDL-1 or NADGE Link-1 links.

b. One TADIL-A and one TADIL-C link.

c. 500 air and surface tracks.

d. Message forwarding.

e. Moving participating units.

f. Message handling for JINTACCS Intelligence and air operations.

g. Scripting for ATDL-1, NADGE Link-1, TADIL-A, and TADIL-C.

h. Four ULMS and MDT links.

i. MTACCS message handling.

j. JINTACCS message handling for fire support, operations control and amphibious operations.

k. Scripting for ULMS and MDT.

Figure 7.1 Simulation/Test Facility Capabilities.

The accumulation of these capabilities will satisfy all presently known test requirements for the TDCC, TACC, TAOC-85 and MIFASS. Additional capabilities can be implemented in a modular fashion without modifying the basic system configuration.

3. Software

The only feasible DoD-approved high order programming languages are CMS-2, ADA and FORTRAN. CMS-2 is implemented on military computers (CP-808, AN/UYK-7 and AN/UYK-20). The CMS-2 compiler also operates on the PDP-11 and VAX-11/780. Since the proposed simulation facility will be hosted on a commerical computer, ADA and FORTRAN seem to be the most feasible software approaches. ADA is scheduled to replace CMS-2 as the Department of the Navy standard programming language for embedded computer systems during 1983-4. ADA compilers are available for military and commerical computers and will be available for minicomputer and microcomputer systems during this year. ADA is, in fact, a strong contender to FORTRAN-77.

4. Hardware

Table (XXXI) lists the minimum requirements which will accomodate the test facility requirements.

TABLE XXXI

Hardware Requirements

ITEM	MINIMUM REQUIREMENT
Direct Memory Access Bandwidth	2 megabits
Direct Addressable Memory	256 Kilobytes
minimum Memory	1 megabyte
Operating System	Multi-tasking
High Order Programming Language	ADA/FORTRAN-77

The VAX 11/780 is one of the few state-of-the-art computers with the minimum direct memory access bandwidth requirement capabilities. The VAX-11/780 is considered the most efficient "number cruncher" within its category of computers.

B. VAX-11/780

1. Description

The VAX-11/780 is a high-performance, multiprogramming computer system. The processor has a 32-bit architecture based on the PDP-11 family of 16-bit computers. While using addressing modes and stack structures similar to those of the PDP-11, the VAX-11/780 provides 32-bit addressing and 32-bit arithmetic. The instruction set and hardware implement high-level language constructs and operating system functions. The VAX-11/780 is a multi-user system for both development and application system execution. It is highly reliable and contains built-in hardware and software protection mechanisms to ensure data integrity and system availability. The computer provides on-line diagnostics, error detecting, verification of system integrity and automatic recovery features. It is both flexible and extendible and provides applications the capability to provide their own command interfaces to users.

The VAX-11/780 is an extension of the PDP-11 family architecture. It executes non-privileged PDP-11 instructions in its compatability mode, utilizes PDP-11 data types and instructions and supports compatability languages and file and record formats.

2. Hardware Components

The major components of the VAX-11/780 are the processor, peripherals, operating system, languages and network services. Table (XXXII) lists the major capabilities of the hardware components.

TABLE XXXII

VAX-11/780 Hardware Capabilities

COMPONENT	DESCRIPTION
Processor	CPU, Synchronous bus, microcomputer console, 2 megabits memory, 2 peripheral buses
Peripherals	Small and large capacity disk drives, magnetic tpaes, hard copy and video terminals, printers, card readers
Operating System	Virtual memory manager, system services, command language, operator tools
Languages	VAX-11 MACRO, PDP-11 BASIC PLUS-2, PDP-11 COBOL-74, CMS-2, linkers, editors, librarians, debuggers
Network Services	DECNet network software, interprocessor communication link

3. Compatibility

When the VAX computer was designed, the need to establish a high level of compatibility with the large, well-established PDP-11 computer family was identified. "VAX represents the natural growth direction for many installations using PDP-11 machines and programs: to ease the growth, to quicken program transition, and to protect prior customer investment, it was important that VAXes displayed good compatibility features [Ref. 4]."

The PDP-11 and VAX-11/780 systems have almost identical FORTRAN, BASIC, COBOL, ADA, and CMS-2 languages. The VAX-11/780 can execute a subset of the PDP-11 16-bit instructions in the compatability mode, the operating system provides functionally equivalent system services as the PDP-11 RSX operating system, the development package allows PDP-11 operating system system generation facilities, the record management services are upward compatible with PDP-11 resources and DECNet/VAX package supports the PDP-11 system image "down-line" loading. The features make the VAX-11/780 an ideal host system to PDP-11 systems in a distributed processing environment by reducing the requirement for programmer/operator retraining. Figure 7.2 depicts a typical resource sharing environment.

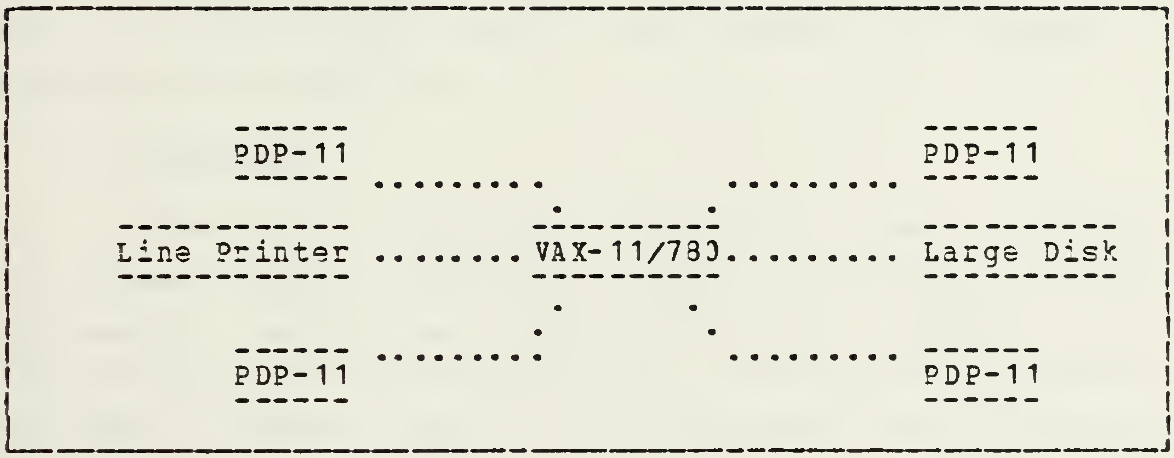

Figure 7.2 VAX-11/780 Distributed System.

C. CONCLUSIONS

1. Concepts

This paper describes the major resources utilized at the Marine Corps Tactical Systems Support Activity (MCTSSA) to test and develop tactical data systems. The existing hardware mixture will not support the increased requirements of MCTSSA and an integrated simulation/test facility should be established to accomodate its ever-increasing workload and responsibilities. The issue of training analysts, programmers and technicians to maintain the conglomeration of necessary hardware and software components which support MCTSSA's requirements can in itself consume another independent research topic. MCTSSA's designation as the primary software support activity for tactical data systems requires that it be equipped with the hardware to support a simulation/test facility.

2. Criteria

The current and future demands for computer support far exceed MCTSSA's existing capacity. The automated data processing demands are characterized by: hands-on use, interfaces with other equipment and the use of experimental software. Systems which do not represent state-of-the-art in computer technology would be of little benefit. The unique vendor (Digital Equipment Corporation) capability allows for tremendous flexibility and growth in the future.

The VAX-11/780 computer is considered a logical, economic/cost-effective upgrade which will satisfy the requirements because of both increasing program workload and data link simulation software testing. The VAX-11/780 compatability mode allows users to run existing PDP-11 software on it with no reprogramming and allows programs compiled on the VAX to run on existing PDP-11's.

Determination of the specific hardware components and software options to be acquired with the two VAX-11/780's to support MCTSSA's mission is extensive and involved and should consume an independent research study.

APPENDIX A
COMMUNICATIONS FOR MARINE CORPS TACTICAL SYSTEMS

Tactical military communications are established for the primary purpose of enabling the military commander to exercise command and control of his assigned combat forces. Another purpose of the communications is to facilitate the transfer of information. As the distances involved increase the commander is more and more dependent on the flow of information. The fundadmental requirements for effective tactical communications are reliability, security, speed of service and flexibility. The systems must be responsive, survivable, economical and simple. [Ref. 5]

The demands of differing tactical scenarios tend to justify a variety of types of communication equipment. Current Marine Corps communication equipment are of two types: single-channel netted radios and multi-channel switched system. Historically tactical doctrine has specified exact types of radio nets required to support tactical situations. The first type either links a headquarters to its subordinate organizations for all purposes except operational coordination. These nets are called command nets. They are hierarchical in nature and link a command both to higher authority and its subordinate units. The second type links operational personnel with their counterparts at the next organizational level. These nets are called tactical nets. Tactical nets are also hierarchical. A third type net is not hierarchical and is called a functional net. It links personnel involved in the same functions to all other organizations, for example a logistics net.

Very high frequency or ultra high frequency are used. Voice dominates the tactical and functional nets and teletypewriter dominates the command nets. Radio nets are simple, survivable, reasonably reliable, secure and responsive. They are not economical nor is their capacity sufficient to accomodate many circumstances.

Radio transmissions produce the major drawback by allowing the enemy to pinpoint transmission locations. Telephone communications provide an alternative to the radio. The telephone systems are more economical but extremely cumbersome to install and highly immobile. Telephone communication systems in the military environment have thus not achieved acceptance. The Marine Corps currently has automatic tactical switching equipment in its inventory. The most significant drawbacks to the current Marine Corps tactical telephone system are its lack of mobility and its lack of security. The switching equipment provide for digital voice communication. Electronics within the Marine Corps extends to the entire spectrum of command and control systems. A goal of Marine Corps communication is to improve the functioning of command centers through the use of automation via digital electronics. These centers are the command and control centers. The Marine Tactical Command and Control Systems will accomodate the above goals.

Each command and control program is considered as a number of centers that exist at various locations with a requirement to communicate with other centers at other locations. The following principles of these command and control systems are universal in nature and apply to all command and control systems, be they associated with airlines, traffic monitoring, banks or military combat systems: computer power is cheaper than transmission media, automating a distributed system increases the amount of communication required, automated systems communications

requirements naturally consist of frequently sent, short messages, the characteristics of communications requirements precludes dial-up telephone systems, lower capacity, full period circuits are not an effective solution, automated systems should be designed to use existing communications and not develop their own and systems must be designed to degrade gracefully as the communications degrade.

APPENDIX B
TEST AND EVALUATION

Test and evaluation has played an important part in the significant improvements made in Defense systems acquisition. Prior to the 1970's emphasis was placed on the delivery of a complete system development and procurement. The theory was that a sufficiently well-defined requirement would result in a deliverable product at a predetermined estimated cost. Unfortunately this method was ineffective because of initial ill-defined requirements, unverified inputs and large cost overruns.

The key issue in developing new management policies in order to review acquisition programs was measurements of program progress as compared to program goals and objectives, and the ability to make a decision whether to continue, reorient or cancel the subject program. Test and evaluation is a means for making such measurements.

Definitions.

There are two kinds of test and evaluation conducted in the systems acquisition process: Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E). DT&E is that testing conducted by or under the supervision of the development agency who will evaluate the technical performance of prototype equipment. The testing is generally conducted by skilled technicians and engineers under carefully controlled conditions. OT&E is that testing conducted by military personnel to determine the degree to which new equipment fulfills military operational requirements. The OT&E is conducted under conditions that duplicate as closely as possible the environment expected in

field operations. Further, OT&E is conducted on early production models as well as on research and development prototypes of new equipment.

DT&E serves two important functions in the system acquisition process. First, it assists in the actual design and development of system. In this role DT&E is an integral part of the normal development process in which initial designs are converted to hardware. The hardware is tested, deficiencies noted and the design is modified as necessary. This process is repeated until the system hardware reaches a final design configuration. This initial feedback system provides essential information required to proceed from the "paper" design into fully developed hardware. Secondly, DT&E provides important information on the progress of new system development. The progress is ascertained by comparing measured system performance with a set of goals and objectives which have been established for the program. The measurement of the maturing system involves such characteristics as reliability, weight, etc. Individuals sufficiently familiar with the maturing process can determine what performance levels should be attained by the system at various stages of development. Development tests then can be performed at frequent points in the program and provide a decision maker with information on the rate of growth of the system. Finally, a prediction of final system performance can be provided by comparing performance level progress with similar systems.

OT&E, like DT&E, also provides essential feedback information to the decision makers by comparing system operational performance with program goals and objectives. Since OT&E that is conducted before system production involves the testing of prototypes, to predict final system operational performance, test results must be extrapolated. The degree of extrapolation will depend primarily on the

realism of the simulated test environment. OT&E is concerned with evaluating purely operational as opposed to technical factors in the system and gives more emphasis to predicting future performance rather than evaluating current performance. The combination of OT&E and DT&E provides the most effective means to predict mature performance [Ref. 6].

Roles.

The primary role of the Test and Evaluation (T&E) process is to provide information during the acquisition process related to the following two questions:

1. What is the current program status?

2. What is the likely outcome of the program?

This is exactly the kind of information the T&E provides. It is apparent that T&E is quite important not only for major production decisions but for most other decisions made during the life of an acquisition program. For major defense program T&E impacts on the acquisition process primarily through the operation of the Defense Systems Acquisition Review Council (DSARC); MSARC for the Marine Corps. When a program reaches a major milestone the DSARC/MSARC meets to consider if the program should be advanced to its next phase. The MSARC plays an important role in the test and evaluation process. Independence and objectivity are quite important to the T&E assessments. Since most DT&E is an integral part of the systems design and development process, it is rightly conducted or controlled by the developing agency. Since developing agencies tend to be success oriented, the effects of such potential biases must be reduced by providing independent assessment and reporting of testing.

OT&E provides an estimate of how the system will perform in the operational environment. Short of actual warfare, operational testing is the ultimate measure of an acquisition program's output and as such will normally receive considerable emphasis when decisions are to be reached. Effective operational testing requires as much test realism as possible consistent with resource constraints and hardware status. This means the use of representative models of production systems, the participation of typical operational personnel in testing, and accurate simulation of both the threat and physical environment. Several others factors must be considered in providing for effective operational testing. Operational test designs must allow for the exercise of systems over a reasonable range of operational conditions. Conclusions on the overall effectiveness of a system cannot be based on a single set of conditions that may represent only a small percentage of likely tactical situations. The scope of testing must allow for all significant interaction between the system being tested and other systems with which it must function in the operational environment. Finally, it is important that objective measurements of a system's performance in simulated operational employment be made without compromise to realism.

Certainly the most important aspect of the effective utilization of T&E in the acquisition process is the establishment of meaningful program goals and objectives whose attainment is to be measured by test. The task requires that operational forces provide information on critical capabilities needed to meet particular operational requirements. The test community must provide inputs on test feasibility and test facility requirements. Early on OT&E may be needed for the following reasons:

1. In considering systems concepts during the early stages of a program, we need to know if these concepts are technically viable or tactically sound.

2. To have any impact on the research and development phase of a program, OT&E should be conducted much earlier than just before major production decisions.

3. Cost and schedule impact can be minimized by early detection and correction of operational deficiencies.

4. Initiation of limited production before the major production decision has resulted in significant commitments of procurement funds prior to the major production decision.

T&E can provide an adequate transfer of "lessons learned". Often a deficiency discovered during T&E is nearly identical to that discovered on past or present programs. T&E can play a significant role in the recurrence of previous deficiencies. T&E has become a firmly established integral part of the systems acquisition process. The ultimate payoff of the T&E process is maximum military capability for the fewest dollars possible.

Policy.

The testing part of (T&E) denotes the actual testing of hardware/software via models, prototypes, production equipment, computer programs to obtain data which is valuable in developing new capabilities or making decisions. Evaluation denotes the process whereby data are assembled and analyzed to aid in making systematic decisions. T&E involves the deliberate generation of data concerning the nature of an emerging system and the creation of informaton useful to technical and managerial personnel who control development. It is the physical testing, experimentation and analyses performed during the course of development and the introduction and employment of a new system.

T&E is an integral part of all phases of the development of systems. Testing provides information for a number of purposes: information for development, information for milestone decisions, and information for effective operational utilization.

Test and evaluation shall begin as early as possible and be conducted throughout the system acquisition process. DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications. It includes hardware/software integration, related software, and prototype or full-scale engineering development models of the system. DT&E will be accomplished before Milestone I to assist in the selection of alternative system concepts. Before Milestone II DT&E will identify the preferred technical approach, to include technical risks and feasible solutions. Before Milestone III adequate DT&E will ensure that engineering is reasonably complete and that all significant design problems have been identified and their solutions imminent. After Milestone III DT&E will be an integral part of the development, acceptance and introduction of system changes to improve the system.

OT&E is conducted to estimate a system's operational effectiveness and operational suitability, identify needed modifications, and provide information on tactics, doctrine, organization and personnel requirements. Initial OT&E must be accomplished prior to the Milestone III decision. One major field agency shall be responsible for managing operational testing and for reporting test results and its independent evaluation of the system. OT&E shall be accomplished in an environment as operationally realistic as possible. Typical operational and support personnel will be used to obtain a valid estimate of the user's capability to operate and maintain the system when deployed. During

system acquisition before the Milestone I decision OT&E will assess the operational impact of possible technical approaches and assist in selecting alternative system concepts. Before Milestone II OT&E will be accomplished to examine the operational aspects of selected alternatives and estimate the potential operational effectiveness and suitability of each. Before Milestone III is completed OT&E will ensure that items tested are sufficiently representative of the expected production items and that a valid assessment can be made of the system expected to be produced. After the Milestone III decision during initial production and deployment of the system OT&E will ensure that initial production items meet operational effectiveness in order to meet performance goals.

Developmental and operational tests may be combined when clearly identified and significant cost and time benefits will result. A continuing goal must be early detection of major system deficiencies if such deficiencies exist. Early detection and correction of deficiencies via T&E can result in more operating force capability and less likelihood of costly programs. [Ref. 7]

APPENDIX C

GLOSSARY

ADA	Navy standard high order programming language
ASRT	Air Support Radar Team
BASIC	A high order programming language
Baud	Bits per second
CMS-2	UNIVAC-written Navy standard programming language
COBOL	Common Business Oriented Language
COMM	Communication
COMSEC	Communications Security
CP	Command Post
CRT	Cathode Ray Tube
C2	Command and Control
C3	Communications, Command and Control
DAS	Direct Air Support
DASC	Direct Air Support Center
DCP	Data Communications Processor
DCT	Digital Communication Terminal
DECNet	Digital Equipment Corporation Network
DoD	Department of Defense
FASC	Fire and Air Support Center
FMF	Fleet Marine Force

FORTRAN Formula Translation

FSC Fire Support Center

FSCC Fire Support Coordination Center

IHAWK Improved Homing-All-the-Way Killer

I/O Input/output

IOC Initial Operational Capability

JINTACCS Joint Intelligence Tactical Command and Control

LFICS Landing Force Integrated Communication System

MAGTF Marine Air Ground Task Force

MASS Marine Air Support Squadron

MATADOR Marine Tactical Data OFF-line Reduction Program

MATCALS Marine Air Traffic Control and Landing Systems

MAW Marine Aircraft Wing

MCTSSA Marine Corps Tactical Systems Support Activity

MTACCS Marine Tactical Command and Control Systems

NADGE NATO Air Defense Ground Environment

NATO North Atlantic Treaty Organization

SIMTRACC Simulator, Trainer, Command and Control

TACC Tactical Air Command Central

TACFIRE Tactical Fire Direction System

TADIL Tactical Digital Information Link

TAOC Tactical Air Operations Central

TDCC Tactical Data Communications Central

TRI-TAC	Tri-Services Tactical Communication System
TSP	Test Support Program
ULMS	Unit Level Message Switch

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